Northeast Salmon Team Fact Sheet Collection

Managing the Impacts of Cormorant Predation on Smolts

Atlantic salmon smolts face many challenges as they migrate from freshwater into estuarine and marine environments. First, although smolts decrease predation risks in freshwater by schooling and traveling at night, these behaviors tend to break down when they reach estuarine environments. During this time, dramatic physiological changes take place as smolts develop a tolerance for salinity. Consequently, a smolt may take many tide cycles to fully transition into a marine environment. While they delay, smolts are exposed a new complex of diurnal predators (i.e. those that are active during the day) including seals, piscivorous (fish-eating) waterbirds, and even other fish. The osmotic stress caused by the smoltification process may make smolts especially vulnerable to these predators.

Today, a myriad of anthropogenic factors further elevates a smolt's predation risks as it enters saltwater. These include (but are not limited to) the disorientation, injuries and congregating behavior associated with dams and the decreased abundance of other diadromous fishes that historically acted as a prey buffer by providing a robust alternative food source for predators.

With similar body size and numbers that historically exceeded salmon smolt populations by several orders of magnitude, pre-spawn adult alewives (bottom) likely served as a buffer for salmon smolts (top) from predators such as seals and picivorous waterbirds. Like salmon, abundance of alternative prey species has declined and with them their prey buffering capacity.

Double-crested cormorants roosting in Penobscot Bay. These waterbirds may be a significant source of smolt mortality.

The Northeast Salmon Team's (NEST) ultrasonic telemetry data suggest that although the majority of smolts successfully migrate through the freshwater environments of Maine's coastal river systems, sometimes less than half successfully enter the Gulf of Maine. Given its rookery locations and long-standing reputation as an important predator of emigrating smolts, NEST researchers believe the double-crested cormorant (*Phalacrocorax auritus)* represents a potentially large source of smolt mortality. Breeding pairs of double-crested cormorants in Maine have increased significantly since the late 1970s and smolts are a frequent prey item. As such, NEST researchers carried out an adaptive management experiment to assess the feasibility of reducing their predation on Atlantic salmon smolts.

A cormorant rookery in Narraguagus Bay.

The Cormorant Exclusion Study

Like other salmon rivers in Maine, NEST researchers have observed a steady decline in the production of naturally reared smolts (i.e. those resulting from natural reproduction or stocked as fry) on the Narraguagus River. Coupled with a strong cormorant presence, this system provided an ideal location to conduct the cormorant exclusion study in 2004 and 2005.

The cormorant exclusion study area can be broken down into three distinct "zones" based largely on their salinity. These include the freshwater, tidal estuarine and "nearshore" marine zones. The lower portion of the freshwater zone (approximately the last two km) marks the beginning of feeding areas favored by cormorants. These birds pose a threat to smolts throughout this zone and the estuarine environment (~ eight km) as well. Once smolts reach the nearshore marine environment, risk of predation by cormorants decreases significantly.

Cormorant harassment activities occurred five days per week in 2004 and four days per week in 2005 for the duration of the smolt emigration period (April and May). Researchers used several harassment techniques to disperse cormorants from study sites on the lower Narraguagus River and estuary. These included pyrotechnics (shell crackers and screamers), lasers, and human approach (on foot and in a boat). The technique used depended on accessibility, proximity to residential areas and the presence of bald eagles. Cormorants were generally left alone once they dispersed outside of the study area.

Collaborator Adam Vashon uses a screamer to disperse feeding cormorants (above). Pyrotechnics and other techniques were used to disperse cormorants from their feeding areas on the lower Narraguagus River and estuary during the peak smolt migration period.

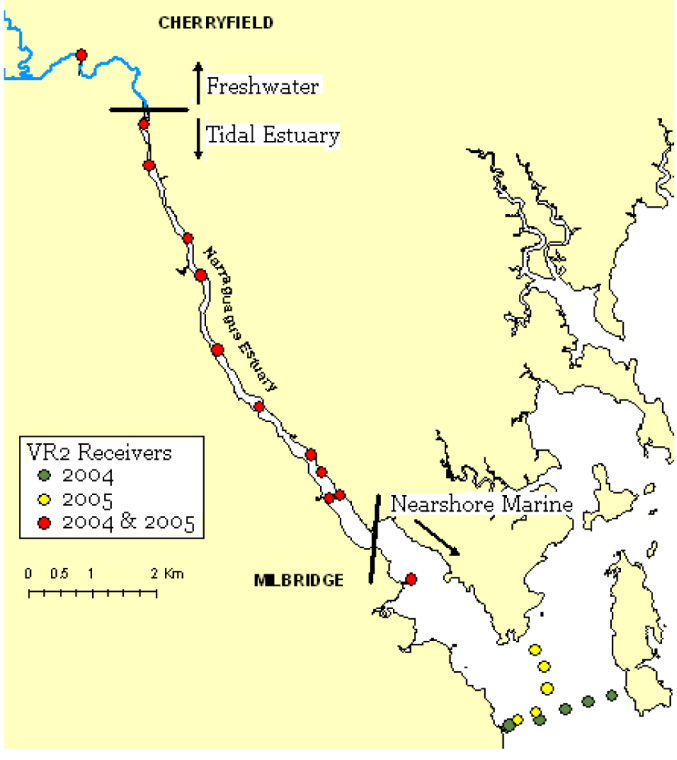
Researchers assessed the effectiveness of non-lethal cormorant exclusion activities as a means of reducing predation on out-migrating smolts with two methods: time lapse photography and ultrasonic telemetry. Time lapse photography allowed researchers to monitor and visually assess the impact of harassment activities on cormorant presence/absence, foraging and behavior and thus develop a summary of the harassment effect. Automated digital cameras were deployed for the study's duration, taking 14 photos per day in 2004 and 65 per day in 2005.

A digital photo captured by an automated camera located on the lower Narraguagus River.

Concurrently, researchers used ultrasonic telemetry to track the migration of smolts through the study area and relate the success of migrants to the occurrence of harassment activities. To conduct this portion of the study, NEST researchers deployed fixed-site automated fish identification receiver (VR2) arrays throughout the lower freshwater, estuarine and nearshore zones. They then surgically implanted ultrasonic transmitters, or "pingers," into naturally reared smolts collected at freshwater rotary screw trap (RST) sites.

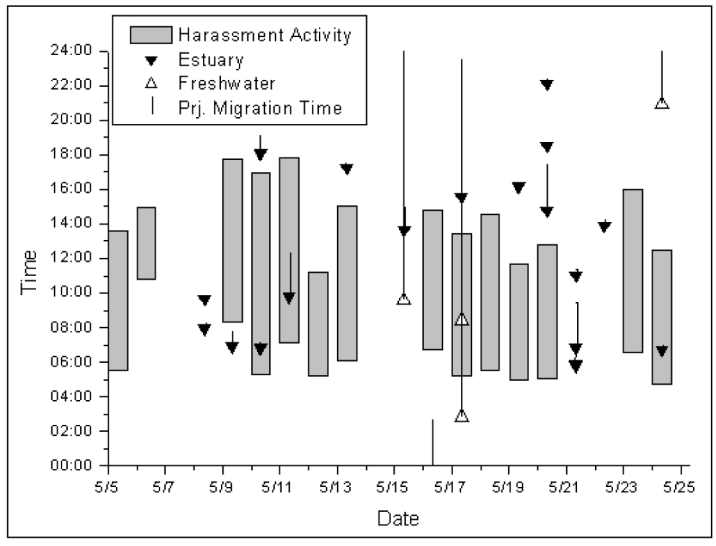
Next to a quarter for scale, a pinger (left) is surgically implanted into one of 140 naturally reared smolts used in the study (right).

After the surgery, researchers released the smolts downstream of the capture sites within minutes of their recovery. VR2 arrays are deployed to prevent out-migrating smolts from going undetected unless physically removed from the system (e.g. by a predator such as a cormorant). Smolts detected by the lower freshwater, estuarine AND outermost nearshore VR2 arrays are assumed to have evaded cormorant predation and successfully migrated into the Gulf of Maine.



Map depicting the freshwater, tidal estuary and nearshore marine zones of the Narraguagus River. VR2 receivers deployed throughout the study area allowed NEST researchers to track emigrating smolts.

Time lapse photography documented fewer cormorants on harassment days and the highest counts of cormorants on days when no harassment took place. Telemetry data suggest that although most smolts successfully migrated through the lower stretches of the freshwater environment, the number of unsuccessful migrants increased as they entered estuarine and nearshore marine environments.



This graph illustrates that only four smolts were last detected during times when cormorant harassment activities were occurring. The projected migration time is simply an approximation of the amount of time a smolt will take reach the next downstream VR2 array.

Although telemetry data indicated that smolts were still lost on days harassment took place, most (> 80%) occurred outside of harassment area or on days when harassment activities did not take place. Thus, harassment activities *did* appear to successfully displace cormorants and change their behavior during times and in areas where they posed the greatest predation risk to out-migrating smolts.

Depending on the finalized and forthcoming results of this adaptive management experiment, NEST will take one of four alternative approaches related to managing the impacts of cormorant predation on smolts. These options include any one of the following:

1) A continuation of the current non-lethal cormorant exclusion program,
2) An expanded (seven days per week throughout the smolt emigration period) non-lethal cormorant exclusion program,
3) A lethal cormorant exclusion program, or
4) No action.

The Northeast Salmon Team (NEST) operates within the Northeast Region of NOAA Fisheries Service to promote the recovery and future sustainability of Atlantic salmon.

We are composed of fisheries managers and scientists jointly based out of the Orono, Maine Field Station; scientists based out of the Woods Hole, Massachusetts Northeast Fisheries Science Center (NEFSC) and Narragansett, Rhode Island Laboratory; and managers based out of the Gloucester, Massachussets Northeast Regional Office (NERO).

Please visit our website at **http://www.nefsc.noaa.gov/salmon/**